Earth's Hydrosphere
ES-5 The student will demonstrate an understanding of Earth's freshwater and ocean systems.

Key Concepts for ES-5:
Surface water: water cycle; lakes, rivers and drainage basins, wetlands
River systems: stages in river development – youthful, mature, old, rejuvenated
Groundwater: karst topography, chemical weathering, sinkholes and caverns
Seawater/Freshwater: physical properties, chemical properties
Shoreline interactions: waves, currents; shoreline features
Shoreline control: jetties, breakwaters, groins; sand dune vegetation anchoring
Transfer of energy: surface currents, deep currents; photosynthesis, chemosynthesis
Water pollution: point and nonpoint sources; groundwater pollution, ocean pollution

ES-5.1 Summarize the location, movement, and energy transfers involved in the movement of water on Earth's surface (including lakes, surface-water drainage basins [watersheds], freshwater wetlands, and groundwater zones).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 6th grade summarized the dynamics of the water cycle including surface-water flow and groundwater flow. In 7th grade students studied the location and movement of water on Earth's surface in groundwater zones as well as surface-water drainage basins making them important to ecosystems and human activities. In Earth Science these concepts will be further studied as energy transfer is attributed to this continual movement of water on Earth.

It is essential for students to know that Earth's water supply is continually being recycled across Earth's surface in a process known as the *water cycle*. Energy from the Sun is the driving force for this cycle. The mechanics of the water cycle helps explain the variations in the amount of water available throughout the world. As water returns to Earth as precipitation, it may flow down slope along Earth's surface as runoff. Runoff may reach a stream, river, lake or wetlands area in its eventual surface flow toward the ocean.

Lakes Students should understand the conditions for a lake to form, how a lake is continually supplied with water, and movement of water within the lake.

Streams & Rivers Students should understand how stream systems form as water flows and collects in surface channels.
- Tributaries form as streams flow into each other.
- A large stream is called a *river*, and all tributaries make up a *river system*.
- They should know the factors that affect the speed of water flow and also what would cause rejuvenation of river flow.

Drainage Basin Students should be able to locate and trace the movement of water in a drainage basin, also called a *watershed*, by determining the land area that drains into a particular stream or river system. A *divide* is the high land area that separates one watershed from another.

Freshwater Wetlands A wetland area is land that is covered with water for a large part of the year. Students should know the various types of wetlands, the supply of water for wetlands, and the reasons for change in amount of water within a wetland area.

Groundwater Zones

Water that seeps into Earth's surface becomes *groundwater*.

- Vegetation, rate of precipitation, rock or soil composition are the conditions on the surface that would allow water to move downward into the ground (such as) as well as slope of the land area.
- Once water moves into the ground, zones of groundwater form. Students should understand the relationship of groundwater to the *zone of saturation, the water table, and the zone of aeration*.
- Students should also understand the formation of stored underground water in an *aquifer.*

It is not essential for students to know uses of surface water or groundwater as it moves through Earth's surface. They do not need to know the names for the surface water patterns or the reasons for changes in stream/river flow patterns.

Assessment Guidelines:
The objective of this indicator is to *summarize* information about water flow on and within Earth's surface; therefore, the primary focus of assessment should be to generalize major points about the location, the movement, and the energy that drives water to cycle on Earth's surface.
In addition to *summarize* appropriate assessments may require students to:

- *explain* how the Sun affects the location and movement of water on Earth's surface;
- *compare* the movement of water in a lake with that in a river or *compare* a lake to a wetlands area;
- *illustrate* by using maps the location of a drainage basin and divide; or
- *recall* groundwater zones.

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ES-5.2 Illustrate the characteristics of the succession of river systems.
Taxonomy level: 2.2-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 7th grade were introduced to river systems as they studied drainage basins and divides. Students have not been introduced to the concept in this indicator in any previous grade.

It is essential for students to know some of the physical features of the stages of development as a river system forms.
Youthful/Young Rivers:
The condition of the headwater where water first accumulates to form the young river is important as well as stream channel characteristics. The formation of river valleys, along with waterfalls and rapids, also show a youthful river system. The fast-moving water erodes away rock and soil as it moves over steep inclines.
Mature Rivers:
Well-established tributaries and good drainage in the watershed are characteristics of mature rivers. They carry a larger volume of water and form a broader floodplain. The gradient is less steep than a youthful river. A mature river may *meander* across its channel area. Erosion and deposition take place along the river bends. A meander may even be cut off and form an *oxbow lake*.
Old Rivers:
With an even lower gradient, the old river moves slowly. The river channel becomes deeper. It no longer erodes the land. Few tributaries enter as most have already merged into the mature river. A broad flat floodplain is formed. As a river loses velocity when entering a large body of quiet water, the sediment load drops forming a triangular deposit called a *delta.*
Rejuvenation*:*
When the land over which a river is flowing uplifts or if the base level lowers, the stream takes on the features of a young river again; it rejuvenates. Depending upon the rate of water flow, erosion again takes place cutting the river channel.

It is not essential for students to know the types of stream load or how terraces form along rejuvenated rivers. Methods of controlling water along and within river systems and floodplains are also not essential but may offer interesting discussion as to their use as safety measures and their effectiveness.

Assessment Guidelines:
The objective of this indicator is to *illustrate* characteristics of river system succession; therefore, the primary focus of assessment should be to give or use illustrations such as diagrams, pictures, or word descriptions to show different stages of a river system.
In addition to illustrate appropriate assessments may require students to:
- *compare* the stages of river succession;
- *summarize* changes that occur during the succession of a river, or
- *identify* characteristics of a stage in river succession.

ES-5.3 Explain how karst topography develops as a result of groundwater processes.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students have not been introduced to the concept in this indicator in any previous grade.

It is essential for students to know that water is a powerful agent of erosion at work underground as well as on Earth's surface.
- Groundwater that passes through *permeable* rock dissolves minerals in the rock.
- Water that moves through organic materials and soil may become acidic, chemically weathering the rock as it passes through.
- Rocks that contain calcite, such as limestone, are susceptible to chemical weathering.

Regions where the chemical weathering effects are visible are said to have *karst topography*.
- These features include sinkholes, caverns, and streams that disappear into cracks in the rock emerging in caves or out cracks long distances away.
- Students should understand how sinkholes and caverns form.
- The formation of cavern characteristics such as *stalactites* and *stalagmites* is also essential.

It is not essential for students to know the chemistry of the processes that take place when rocks undergo chemical weathering. The study of wells, springs, hot springs, and geysers is not part of karst topography.

Assessment Guidelines:
The objective of this indicator is to *explain* how karst topography results from groundwater processes; therefore, the primary focus of assessment should be to construct cause and effect models of groundwater chemical weathering resulting in karst topography formations.
In addition to explain appropriate assessments may require students to:
- *summarize* the formation of stalactites and stalagmites;
- *exemplify* types of karst topography; or
- *identify* karst topography features from descriptions, pictures, or diagrams.

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ES-5.4 Compare the physical and chemical properties of seawater and freshwater.
Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 3rd grade located saltwater and freshwater features on Earth. In 5th grade they studied mixtures and solutions, properties of water as a solvent. In Earth Science the study deepens as students have the basic chemistry background to understand in greater detail the properties of these two types of water found on Earth.

It is essential for students to know that freshwater and seawater have unique properties that are important to processes on Earth. Pure water is a chemical compound whose molecule consists of hydrogen and oxygen (formula = H_2O). Water is not chemically reactive. As the universal solvent, water can dissolve many materials into solution.

Freshwater

Freshwater is one of Earth's more abundant and important renewable resources. It can be found within the temperature conditions on Earth in all three states of matter.

- As a liquid, it flows over Earth's surface and into the ground. It takes the shape of various containers on Earth – lakes, ponds, aquifers, and rivers.
- As a solid freshwater is found in glaciers, snowfields, and the ice caps of Earth.
- Water vapor in the atmosphere is the great mover of water from one location to another on Earth.

Freshwater is a mixture that contains more substances than just pure water.

- As water dissolves materials in rock and soil or pollutants in the air, it can form acid solutions that change the atmosphere, precipitation, and land formations of Earth.
- Freshwater has a density of about 1.0 g/cm^3 and freezes at 0°C.

Seawater

Seawater is also a mixture, but it contains more dissolved substances than freshwater.

- It is a solution of about 96.5% water and 3.5% dissolved salts.
- The most abundant salt in seawater is sodium chloride (NaCl).
- Other chloride and sulfate salt compounds are also present.
- Dissolved gases, such as oxygen, nitrogen, and carbon dioxide, are also present along with dissolved nutrients.
- The salinity of ocean water varies from place to place. High salinities are found in areas where evaporation is high or seawater is freezing; low salinities occur where freshwater empties into oceans.
- Other physical properties of seawater include a density of about 1.02 – 1.03 g/cm^3. The freezing point of seawater is lower than freshwater at -2°C.

Both freshwater and seawater respond to solar radiation that strikes the Earth's water surfaces.

- *Visible Light*: Water both absorbs and reflects visible light.
  - Most sunlight that reaches Earth falls on the oceans; this sunlight penetrates the surface and is absorbed by water.
  - Most wavelengths of *visible light* are absorbed, but blue light tends to be reflected.
  - All wavelengths of light are absorbed by about 100m depth, so deep lakes and the oceans are dark except for surface region.

- *Infrared Rays*: Water also has the ability to absorb infrared wavelengths of sunlight.
  - Infrared rays play an important role in determining the temperature of water.
  - Rapidly moving water in fast-moving streams and rivers does not have time to absorb infrared waves.
  - Lakes and ponds, especially shallow ones, become warm as the infrared rays are absorbed.
  - Infrared rays are completely absorbed within the upper zone of ocean water; thus it heats the water only near the surface of the ocean.
  - Surface temperature does vary with latitude – polar seawater is cold or even frozen depending upon the season. Tropical seawater is generally warm all year.
  - Seawater deep in the ocean is very cold.

It is not essential for students to know the atomic structure of a water molecule or how its chemical shape makes it a polar molecule.

Assessment Guidelines:
The objective of this indicator is to *compare* properties of freshwater and seawater, therefore, the primary focus of assessment should be to detect ways that freshwater and seawater are alike or different in regards to their properties.
In addition to *compare* appropriate assessments may require students to:
- *summarize* major points about the properties of freshwater or seawater;
- *interpret* charts or graphs of light or temperature differences with water depth; or
- *recall* the reason water in lakes or the ocean appears blue in color rather than clear.

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ES-5.5 Explain the results of the interaction of the shore with waves and currents.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students were introduced to features along the shore zone in 5th grade, as well as studying the affect that waves, currents, tides, and storms have on the geologic features of the ocean shore zone. They compared the movement of water by waves, currents, and tides. In Earth Science the students will explain these actions with greater understanding of the characteristics and motions of waves and currents causing changes along the shore.

It is essential for students to know the characteristic motion of *water waves*, including the factors that affect the height of a wave. They should know the cause of breaking waves and their affects on the shoreline. *Surface ocean currents* usually only affect the temperature of the shore area waters. *Longshore currents* transport sediment. Since most beaches consist of loose sediments, longshore currents can spread them out in the direction of the current flow along the shore. Large waves are associated with fast moving longshore currents and lots of sediment transport.

Students should have an understanding of *longshore current transport*.
- As a result of wave erosion, longshore current transport, and sediment deposition, the shoreline is in a constant state of change.
- Sediments eroded in one area are moved and deposited in another building various coastal landforms, such as sandbars, spits and barrier islands. Students should know how these features form and change due to wave action and current transport.

It is not essential for students to know about the cause and effects of tides on the shore zone. They do not need to study density ocean currents, turbidity currents, or upwellings with this indicator.

Assessment Guidelines:
The objective of this indicator is to *explain* the results of interactions of the shore with waves and currents; therefore, the primary focus of assessment should be to construct cause and effect models of how waves and currents cause changes along the shoreline.
In addition to explain appropriate assessments may require students to:
- *compare* the effects of strong wave action with gentler wave action;
- *summarize* the action of longshore current transport; or
- *identify* shoreline features caused by wave action or longshore transport.

ES-5.6 Summarize the advantages and disadvantages of devices used to control and prevent coastal erosion and flooding.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: Students have not been introduced to the concepts in this indicator in any previous grade.

It is essential for students to know that in coastal areas structures such as seawalls, groins, jetties, and breakwaters are built in an attempt to prevent beach erosion and destruction of oceanfront properties.

- Students need to study each of these structures to determine the advantage each gives to control and prevent coastal erosion and flooding.
- Where structures are not built, beach nourishment, which involves adding large quantities of sand to the beach system, is sometimes used.
- Along with advantages, students need to study the disadvantages of these structures as they are built along the coastlines, as well as problems with beach nourishment.

An overall understanding that students need to have in regards to this concept is that the shoreline is not stable; shorelines continually undergo change. Erosion and deposition are natural processes of the interaction of ocean water with coastal features.

It is not essential for students to evaluate or judge the value of devices built along the coastal areas.

Assessment Guidelines:
The objective of this indicator is to *summarize* advantages and disadvantages of devices built along coastal areas; therefore, the primary focus of assessment should be to generalize major points about why these devices are needed to control and prevent erosion and flooding and why they are drawbacks to the natural change of the coastline.
In addition to summarize appropriate assessments may require students to:

- *explain* the effect a structure would have if built along the coastline;
- *identify* the reason for structures to be built along the coastline; or
- *exemplify* structures built along coastal areas.

ES-5.7 Explain the effects of the transfer of solar energy and geothermal energy on the oceans of Earth (including the circulation of ocean currents and chemosynthesis).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students have not been introduced to the concepts in this indicator in any previous grade.

It is essential for students to know that solar energy penetrating the surface water region of the ocean and geothermal energy from thermal vents deep within the ocean have affects on the movement and chemical reactions that take place in ocean waters.

Ocean currents

Surface currents: As solar energy reaches Earth's oceans most directly in areas near the equator, surface water in that region is warmer.

- The surface ocean water is set into motion by energy from the wind.
- The wind belts determine the direction of the flow, but the Coriolis effect and interaction with continents also help determine surface ocean current direction of movement.
- Warm equatorial surface currents flow and bring warm water to cooler regions.
- Currents coming from areas near the poles where solar energy is less direct are cold currents. As cold currents move toward the equator, they cool the region around them.

Deep currents:

- Water warmed by solar energy near the equator expands, is less dense that cold water, and rises.
- Cold water from the poles is denser, sinks, and moves very slowly beneath warmer ocean water toward the equator.

Chemosynthesis

- Some regions of the ocean are teeming with life due to organisms using solar energy for photosynthesis. The most abundant marine life exists where there are ample nutrients and good sunlight.
- In deep ocean areas where sunlight does not reach, *chemosynthesis* (chemical reactions) supports life near hydrothermal vents, mainly along the oceanic ridge.
  - Microscopic bacteria living in and near the vents perform chemosynthesis and become the bottom of the food web.
  - Through chemosynthesis, the bacteria produce sugars and other foods that enable them and many other organisms to live in this very dark, very unusual environment.

It is not essential for students to know the names of specific warm or cold ocean currents – the explanation here is about solar energy affecting the currents. Students are not responsible for knowing the classification of marine life or the various marine life zones.

Assessment Guidelines:

The objective of this indicator is to *explain* how solar energy and chemosynthesis affect Earth's oceans; therefore, the primary focus of assessment should be to construct cause and effect models of how solar energy affects ocean current movement and life in the ocean, and also how chemosynthesis affects life where solar energy does not reach.

In addition to *explain* appropriate assessments may require students to:

- *compare* surface ocean currents with deep ocean currents;
- *compare* marine life where solar energy reaches with marine life where it is dark;
- *recall* the process of chemosynthesis; or
- *identify* the reason that warm ocean currents exist.

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ES-5.8 Analyze environments to determine possible sources of water pollution (including industrial waste, agriculture, domestic waste, and transportation devices).
Taxonomy level: 4.-B Analyze Conceptual Knowledge

Previous/future knowledge: Students in 5th grade explained how mixing and dissolving of foreign materials is related to water pollution. In 7th grade students explained the implications of depleting and the importance of conserving resources, such as water. In Earth Science this foundation will be deepened as specific sources of water pollution in the environment are analyzed.

It is essential for students to know that water is an essential resource on Earth. Organisms on Earth depend on water for life. Humans depend on water in many ways. Water pollution is an area where humans have an impact on water supplies.

Surface water pollution can be grouped into two main types: point sources and nonpoint sources.

Point sources Point source pollution is generated from a single point of origin. When analyzing an environment for water pollution sources, students may find the source to be a sewage treatment plant for domestic waste, or an industrial site. Improper bacteria and viruses that result from disposal of sewage, or toxic wastes that enter streams can send this pollution downstream into the environments.

Nonpoint sources Nonpoint sources of pollution generate pollution from widely spread areas. Rainwater absorbs air pollutants and may become acidic, bringing down precipitation far from its origin. Rainwater may also drain fertilizers and pesticides from agricultural sites, or wash oil, gasoline, and other chemicals from roads and parking lots. Nonpoint sources are not as easily identified nor as easily cleaned up as point sources.

Groundwater pollution - Not only is surface runoff water a carrier of pollutants, pollution can find its way into groundwater and into the ocean.

Groundwater pollution Some water filled with chemicals, road salt, fertilizer, sewage or other pollutants may find its way into groundwater and aquifers in a region. Once groundwater is contaminated, the pollutants can be very difficult to remove.

Ocean pollution Pollution of ocean water is also a concern. Near-shore regions and estuaries are often the first regions of the ocean to become polluted. Sewage water is the most common source.

In analyzing the sources of water pollution, students need to realize the importance of clean-up efforts and the importance of reducing water pollution. When there is not enough water to go around, water conservation is most important.

It is not essential for students to actually collect water pollution samples for analysis.

Assessment Guidelines:
The objective of this indicator is to *analyze* environments for sources of water pollution; therefore, the primary focus of assessment should be to carefully study environments to determine how the information could identify pollution sources.
In addition to analyze appropriate assessments may require students to:

- *exemplify* the various sources of water pollution;
- *compare* point and nonpoint pollution; or
- *infer* a pollution source from its description.